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Progress Report

PREDATOR INTRODUCTIONS IN 1961 FOR CONTROL OF THE BALSAM WOOLLY APHID AND AN EVALUATION OF ESTABLISHED PREDATORS

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This report is not for publication in whole or in part without prior approval of the chief of this Bureau.

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SUMMARY

Fewer foreign predators were introduced and more emphasis was placed on laboratory testing of predator suitability in 1961. Only six species were shipped to the Pacific Northwest this year, all from Pakistan and India. This brings the number of predators introduced since the biological control program started in 1957 to 22 species and some 61,000 specimens.

Of the six species received in 1961, only one, a chrysopid from India, was liberated in the field. The rest were maintained in laboratory rearing to determine if they could be propagated on the balsam woolly aphid. Test results suggested that none of the laboratory species would have been successful in the field as predators of the balsam woolly aphid. It is too soon to determine results of the field liberation.

Establishment checks of predators liberated before 1961 showed five species established: Two beetles, Pullus impexus Muls. and Laricobius erichsonii Rosen; and three flies, Cremifania nigrocellulata Cz., Leucopis obscura (Hal.) and Aphidoletes thompsoni Mohn. All five species are from Europe. As yet, there are no indications that any of the 11 Asian species liberated in the field will survive in their new environment.

Except for P. impexus, which has been in this region for only one winter, populations of established predators were generally larger this year than last. An increase in numbers of A. thompsoni was particularly notable. L. erichsonii proved disappointing in some areas but still appears to be the most effective predator introduced thus far; in most high elevation areas, populations were large, dispersal was good, and predation on aphid populations significant.

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INTRODUCTION

In 1957, a biological control program was initiated in Oregon and Washington to attempt control of the balsam woolly aphid, Chermes (=Adelges) piceae Ratz. Since then, 22 species and some 61,000 specimens of foreign insect predators have been shipped to this region. This report--the fifth since the program began--summarizes (1) information on the 1961 introductions and (2) status of previous successful liberations. Historical background and administrative details of the program are not reported, nor are methods and procedures of work particularly stressed. Such information is available in previous reports. 1/

1/ Other reports on the predator introduction program in the Pacific Northwest are:

1. Wright, K. H. and R. G. Mitchell. Progress Report. Colonization in Oregon and Washington of Aphidoletes thompsoni - An European Predator of the Balsam Woolly Aphid. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. February 1, 1958.

2. Wright, K. H., P. E. Buffam, and R. G. Mitchell. Progress Report. Colonization of Foreign Insect Predators in 1958 for Control of the Balsam Woolly Aphid. ibid. March 15, 1959.

3. Buffam, P. E., K. H. Wright, and R. G. Mitchell. Progress Report. Predator Introductions in 1959 for Control of the Balsam Woolly Aphid and an Evaluation of Releases to Date. ibid, March 15, 1960.

4. Buffam, P. E. and R. G. Mitchell. Progress Report. Foreign Predator Introductions for the Control of the Balsam Woolly Aphid in the Pacific Northwest; 1957-1960. ibid. May 1, 1961.

COLONIZATION PROGRAM IN 1961

A shift in program emphasis in 1961 saw fewer foreign predators introduced and more attention given to laboratory testing for predator suitability. During the year, only six species, representing 416 adult insects and 254 eggs, were shipped to the Pacific Northwest. All were from Pakistan and India. Of the six species, only one, a chrysopid from India, was actually liberated in the field. The rest were studied in the laboratory to determine if they could be propagated on the balsam woolly aphid. Table 1 shows the source of each predator species shipped to the Pacific Northwest in 1961, the number introduced, and where they were released.

Table 1.--Summary of 1961 field and laboratory releases in the Pacific Northwest

Species	Source	Number released 1/		
		Field	Laboratory	Total
Adalia tetraspilota Wse. (Coleoptera: Coccinellidae)	Pakistan	0	75	75
Ballia diana (Coleoptera: Coccinellidae)	India	0	100	100
Exochomus lituratus Gorh. (Coleoptera: Coccinellidae)	Pakistan	0	55	55
Chrysopa sp. I 2/ (Neuroptera: Chrysopidae)	Pakistan	0	43	43
Chrysopa sp. II (Neuroptera: Chrysopidae)	India	29 34-E	104 254-E	133 288-E
Undetermined Hemerobiidae (Neuroptera)	India	0	10	10
Total		29 34-E	387 254-E	416 288-E

1/ Suffix "E" indicates eggs; the remaining predators were adults. The 34 eggs liberated in the field were obtained from laboratory rearings in Portland.

2/ The two neuropterans received were identified only to genus, Chrysopa; for distinction they are called species I and II.

Introduction and Liberation

Predators shipped to the Pacific Northwest in 1961 were collected in the southern Himalaya Mountains by Entomologists Dr. M. A. Ghani of Pakistan and Dr. V. P. Rao of India. Both work for the Commonwealth Institute of Biological Control (CIBC), at laboratories in Rawalpindi, Pakistan, and Bangalore, India. Services of CIBC personnel and equipment were contracted for by the United States Government under terms authorized by Public Law 480. Administration of the U. S. part of the program was largely the responsibility of the Foreign Research and Technical Programs Division of the Agricultural Research Service (ARS), U. S. Department of Agriculture.

Insect predators shipped to the United States were sent for screening, and sometimes further rearing, to the ARS laboratory at Moorestown, New Jersey. They were then routed, via air mail, to the Forest Service Experiment Stations at Asheville, North Carolina, or Portland, Oregon.

Insects sent to Portland were in the adult or egg stage and were packed in pint-sized ice cream containers. Mortality of adult predators in transit from New Jersey to Oregon was negligible, amounting to less than 1 percent. Losses in egg shipments, however, were quite severe: Of 254 chrysopid eggs in two shipments, only 126 survived. Damage was mainly caused by eggs being crushed between the paper substrate to which the eggs were attached.

Most predators held for laboratory rearing were confined in insectary cages of the type shown in figure 1. 3/ Also placed in the cages were aphid-infested logs (waxed at both ends to maintain freshness), water-soaked sponges for moisture, and honey for supplemental food. Constant 24-hour lighting (except for the chrysopids which were covered at night) was provided by fluorescent desk lamps. Temperature in the rearing rooms ranged from 70° to 80° F. through most of the year, but was allowed to drop to 40° to 60° F. during December, January, and February.

Early shipments of Chrysopa I and II were caged in the manner just described, but later, on recommendation of Dr. L. B. Parker of the Moorestown laboratory, procedures were changed to encourage greater oviposition. The revised rearing method used a half-gallon ice cream container as a cage; it was lined with black construction paper and covered at the ends with fine, plastic screen. The paper liner served as an oviposition site which was easily handled in the laboratory; the black color of the paper aided materially in detection of the eggs. Food was supplied by streaking honey against one end of the cage. For moisture, a water-saturated sponge was taped against the screen at the other end. In addition, one squirt of water from an atomizer was sprayed against the honey-streaked screen each day.

3/ Insectary cage adapted from an older design by Mr. G. L. Finney of the University of California Biological Control Laboratory at Albany, California.

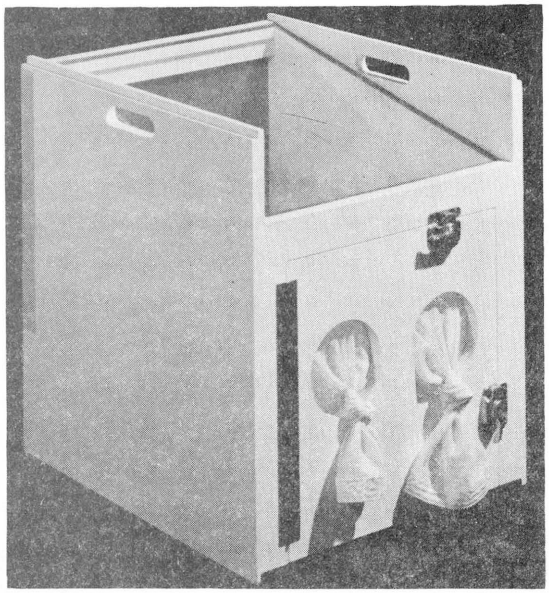

Figure 1.-Cage used for rearing foreign predators in the laboratory

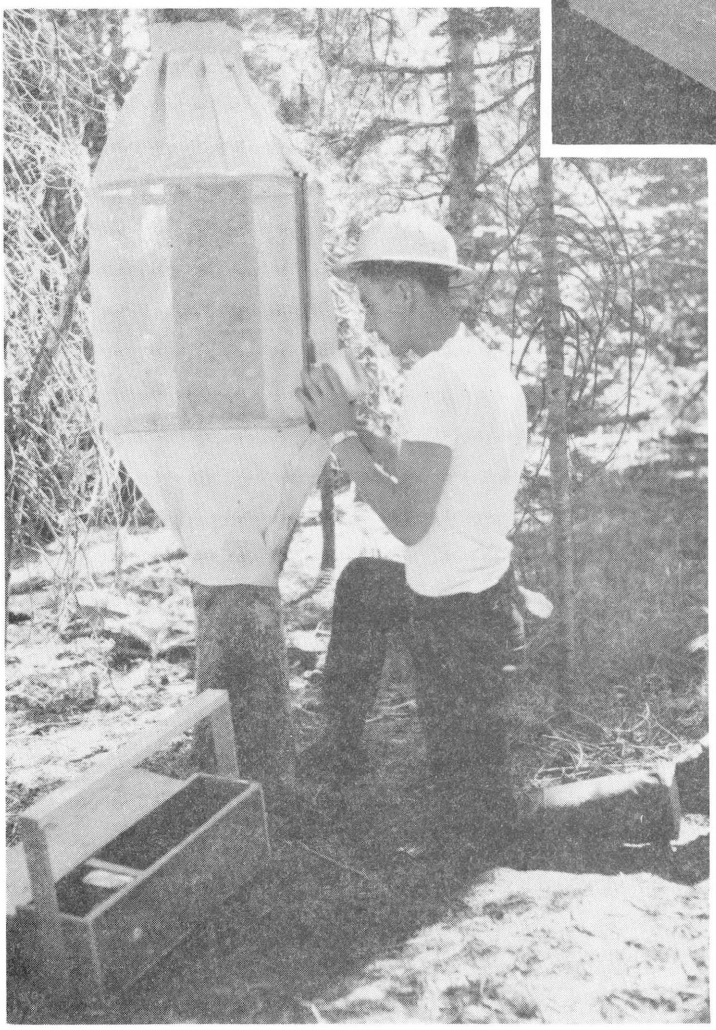

Figure 2.-Liberating chrysopids from India in sleeve cage attached to a heavily infested subalpine fir

The single field liberation in 1961 was made in a sleeve cage attached to an 8-inch (dbh) subalpine fir, Abies lasiocarpa (Hook.) Nutt., with a heavy balsam woolly aphid stem infestation (Fig. 2). The release tree is in a severely infested subalpine fir stand adjacent to U. S. Highway 26, 4.2 miles east of the Summit Ranger Station, Mt. Hood National Forest. Elevation is about 4,000 feet. Liberation was made by R. L. Johnsey and R. G. Mitchell on August 21, 1961. Temperature was 85° F., there was no wind, and the sky was clear. Infestation density on the release tree was about 50 sistentes per square inch of bark surface. The cage was removed from the tree on September 12.

Release Results

Results of laboratory rearings suggest that little or nothing would have been accomplished by field liberating the predators received in 1961. Three species--Adalia tetraspilota Wse., Chrysopa I, and an undetermined Hemerobiidae--ignored the aphid-infested logs altogether. The A. tetraspilota population lived about 8 weeks before it died; Chrysopa I lasted 2 to 4 weeks, and the hemerobiids were gone within 3 weeks.

Ballia diana was only slightly attracted to the balsam woolly aphid. Most of the 100 adults caged on May 23 settled in some secluded spot on the log and remained quiescent until they died. Mortality was first noted on June 5 and continued at a gradual rate until the last insect died on February 12, 1962. During this time, a few adults were observed feeding on the prey and two pairs were seen mating; late in the period, when only two adults remained alive, six eggs were deposited on the aphid-infested log. None of the eggs proved viable, however.

Exochomus lituratus Gorh. appeared to be the most promising predator introduced in 1961. Of the 55 adults caged with an aphid-infested log on May 16, about half immediately became quiescent, but the other half were quite active and fed readily on the aphids. Several pairs were seen mating. Oviposition began within 2 weeks after release and by July 9 a total of 40 eggs was counted; however, none laid to this date proved viable and none were deposited on the log--every egg being indiscriminantly dropped to the cage floor. Later, about July 20, viable eggs began appearing on the aphid-infested log. These eggs soon hatched, and progeny readily fed on the balsam woolly aphid. By February 1, 1962, the population numbered 24 adults (parents and progeny), increasing from only seven parents in September. There has been no oviposition since January 1, but rearings will be maintained in hopes that a population can be developed which will be attracted to the balsam woolly aphid.

Chrysopa II, the only predator liberated in the field in 1961, can not be classified at this time as either a good or unsatisfactory predator. In the laboratory, the insect proved capable of passing through a complete generation on the balsam woolly aphid but not without experiencing considerable mortality in the immature stages. Larvae did considerable wandering and were prone to leave the aphid-infested logs, often starving

to death before they could be found and returned to the prey. Also, larvae showed strong tendencies toward cannibalism, even when the balsam woolly aphid was plentiful. These observations suggest that although C. piceae will serve as a host when nothing else is available, it is not preferred by this predator.

Results of the study using two types of cages further suggested that C. piceae is not a preferred host of Chrysopa II. When using the large cage shown in figure 1, few eggs were laid and then mostly on the sides of the cage. However, it may have been that the environment in the large cages was unsuitable. When the insects were switched to the small ice cream cartons where there was no host present, egg production more than doubled and life span was extended about 5 weeks.

It is too early to determine results of the field liberation of Chrysopa II. Eggs, larvae, and pupae were observed on the tree when the cage was removed after release but nothing was found thereafter. A close check will be made in the area in the spring of 1962.

STATUS OF ESTABLISHED PREDATORS

Of the 18 species of foreign insect predators introduced into the Pacific Northwest through 1960, 6 were from western Europe and 12 were from Asia or Australia (Table 2). None of the Asian or Australian insects have shown indications of establishment while five of the European predators successfully survived one or more winters and have completed at least one life cycle preying on the balsam woolly aphid. This section discusses only the successful predators--two beetles, Pullus impexus Muls. and Laricobius erichsonii Rosen.; and three flies, Cremifania nigrocellulata Cz., Leucopis obscura (Hal.) and Aphidoletes thompsoni Mohn. Status of the other imports have not changed since last year's report.

Laricobius erichsonii (Coleoptera: Derodontidae)

Observations in 1961 showed L. erichsonii firmly established in three areas: Willamette Pass in Oregon, and Green River and Cold Water Creek in Washington. Chief disappointment was the unexplained absence of predators at Black Rock, Oregon, an area where the beetle appeared well established previously. This area will be checked very closely in 1962. Another release locality needing close surveillance in 1962 is the infestation at Wind River, Washington. L. erichsonii appeared in fair numbers in the spring of 1961, but nearly eliminated the small, local prey population available.

Populations at the two Willamette Valley release areas of Monroe and Long Tom River, after dwindling to extremely low levels in 1960, finally disappeared in 1961. It may be that L. erichsonii populations still exist at extremely low levels and will grow again at a later date, but the prospects seem remote.

Table 2.--Foreign insect predators introduced since 1957 for control of the balsam woolly aphid in Oregon and Washington

Species, order, and family	Source	Years released	Number released
Adalia luteopicta Muls. (Coleoptera: Coccinellidae)	India	60	156
Adalia tetraspilota Wse. (Coleoptera: Coccinellidae)	India Pakistan	59, 60, 61	176
Aphidecta obliterata L. (Coleoptera: Coccinellidae)	Sweden Germany	58, 59	1,438
*Ballia diana (Coleoptera: Coccinellidae)	India	61	100
Ballia eucharis Muls. (Coleoptera: Coccinellidae)	Pakistan	59	85
Chilocorus kuwanae Silv. (Coleoptera: Coccinellidae)	Japan	58	135
Exochomus lituratus Gorh. (Coleoptera: Coccinellidae)	Pakistan	60, 61	98
Exochomus uropygialus Muls. (Coleoptera: Coccinellidae)	Pakistan	59, 60	6,682
Harmonia breiti Mader (Coleoptera: Coccinellidae)	India	59, 60	83
Leis dimidiata F. (Coleoptera: Coccinellidae)	India	59	23
*Oenopia sauseti Muls. (Coleoptera: Coccinellidae)	India	60	46
Pullus impexus Muls. (Coleoptera: Coccinellidae)	Germany	60	400
Scymnus pumilio (Wse.) (Coleoptera: Coccinellidae)	Australia	59, 60	2,859
Synharmonia conglobata L. (Coleoptera: Coccinellidae)	India	59, 60	127
Laricobius erichsonii Rosen. (Coleoptera: Derodontidae)	Czechoslovakia Germany	58, 59	10,125
Cremifania nigrocellulata Cz. (Diptera: Chamaemyiidae)	Czechoslovakia Germany	58, 59	1,374
Leucopis obscura (Hal.) (Diptera: Chamaemyiidae)	Maine (Europe)	58, 59	2,785
Leucopis sp. (Diptera: Chamaemyiidae)	Pakistan	59	15
Aphidoletes thompsoni Mohn. (Diptera: Itonididae)	Czechoslovakia Germany	57, 58, 59	34,204
*Chrysopa sp. I (Neuroptera: Chrysopidae)	Pakistan	61	43
Chrysopa sp. II (Neuroptera: Chrysopidae)	India	61	421**
*Undetermined Hemerobiidae (Neuroptera)	India	61	10
		Total predators introduced	61,385

* None liberated in the field; maintained in laboratory rearing.
** Number includes 288 eggs.

Studies of L. erichsonii dispersal revealed moderate spread in most areas where established. Annual rate of dispersal since liberation in 1958 in the two areas most closely studied is shown in table 3.

Table 3.--Annual rate of Laricobius erichsonii dispersal since liberation in 1958 at Willamette Pass, Oregon and Green River, Washington

Time after release	Dispersal distance in feet	
	Willamette Pass	Green River
First year (1959)	75	?
Second year (1960)	850	450
Third year (1961)	1400	640

Dispersal probably would have been greater in the two areas shown in table 3 if the insects would have been forced to disseminate. However, since aphid-infested trees were abundant, there was no need for far-ranging search. In level or gently sloping areas, spread was nearly equal in all cardinal directions. But, on steep slopes (about 100 percent at Green River) most L. erichsonii spread downhill.

L. erichsonii adults and larvae were again observed preying on an unknown species of Pineus (Hemiptera: Chermidae) infesting Engelmann spruce, Picea engelmanni (Parry) Englm. Such infestations are few, however, and do not seem to attract any more beetles than trees infested with the balsam woolly aphid. The addition of a second host may even benefit the program. Subalpine fir in the Pacific Northwest is rather spotty in distribution; therefore, an acceptable prey infesting another tree species should materially aid long-range predator dispersal and population stability.

Predator effectiveness studies in 1961 on three trees at Willamette Pass showed--as last year--L. erichsonii capable of significantly reducing balsam woolly aphid populations. A summary of predator evaluations in 1961 is presented in table 4.

Table 4.--Summary of the 1961 Laricobius erichsonii predator effectiveness study on three trees at Willamette Pass, Oregon

Evaluation tree	Aphid population at time of predator attack*	Peak Laricobius population	Change in aphid population density from 1st to 2nd generation*	
			Protected population	Exposed population
	No. per in.^{2}	No. per ft.^{2}	Percent	
740	7.4	9.4	+ 19.5	-21.2
790	9.6	9.7	+119.0	+22.8
805	15.7	1.0	- 53.0	-57.0

* Counts of aphid populations do not include neosistentes, a stage not susceptible to predation.

As shown in table 4, notable predation was recorded on all three trees evaluated. But only tree 740 revealed true control; that is, reduction of the aphid population to the point where the density of the second generation is less than the density of the first generation. Ordinarily, barring adverse effects due to declining host condition, population density at the peak of the second generation is greater than the first.

Tree 790 presents an example of considerable population reduction due to predation but not true control. While the difference between the two populations is great, density of the exposed aphid population is still climbing; and, provided the tree does not die first and assuming no change in predator effectiveness, the aphid population will eventually reach maximum density, as it would have without predation by L. erichsonii. It can be pointed out, however, that the peak population will be delayed; hence, predation may be important from the standpoint of prolonging the tree's life.

Tree 805 represents an instance where both the tree and the aphid population are dying. Both protected and exposed aphid populations are declining, but the population exposed to predation at a somewhat faster rate.

Aphidoletes thompsoni (Diptera: Itonididae)

Increased numbers of A. thompsoni in 1961 was noted in every area where the insect has become established. Also, the period of larval recovery was much longer than the year before. Cause of the population reductions in 1960 remains unknown. Rearings of field collected larvae at Willamette Pass failed to show any signs of parasitism.

The most encouraging discovery in 1961 concerning this predator was that sizeable Aphidoletes populations have developed at Randle and Cold Water Creek, Washington. It was believed in 1960 that these two colonization attempts had failed. This brings the total number of areas in which A. thompsoni is established to six.

Dispersal studies revealed the greatest spread of A. thompsoni to be 775 feet in 3 years at Monroe, Oregon. The next greatest spread was 525 feet in 2 years at Cold Water Creek and 500 feet in 2 years at Willamette Pass. In most areas, dispersal distance was about the same in all directions. At Willamette Pass, where the prevailing wind is from west to east, the greatest Aphidoletes spread was to the east.

There has been no formal assessment of this predator's effectiveness, but the species shows much promise of becoming a valuable addition to the predator complex. With multiple generations and high populations, the insect should be able to control the balsam woolly aphid, especially if working in conjunction with L. erichsonii. The heaviest Aphidoletes population noted to date has been 85 larvae per square foot of bark surface on one tree at Willamette Pass.

Cremifania nigrocellulata (Diptera: Chamaemyiidae)

Status of this predator has not changed appreciably since last year's report. Populations at Monroe and Corvallis are a little higher than before, and the area occupied by the insect has increased. A maximum spread of 720 feet in 2 years was recorded at Monroe. The small size of the grand fir stand at Monroe will prevent much further local dispersal.

The most significant find in 1961 was that C. nigrocellulata is still surviving at Willamette Pass. One larva was collected about 20 feet from the original liberation tree. This is the first recovery in this area since two larvae were collected in 1958, the year the insect was liberated.

Leucopis obscura (Diptera: Chamaemyiidae)

L. obscura was noted to be abundant at Willamette Pass, the one locality where it became established. Numbers of predator larvae on any one infested tree was not great, but the insect was well distributed throughout the stand. Maximum spread in 2 years was about 1,000 feet.

As yet, there has been no formal assessment of this predator's effectiveness. Observations suggest, however, that at the present density the predator would not be able to control an infestation by itself.

Pullus impexus (Coleoptera: Coccinellidae)

This predator was liberated on June 18, 1960 in a small farm woodlot at Long Tom River, Oregon. Following release, adults were observed feeding on the balsam woolly aphid in limited numbers throughout the rest of the summer. On February 21, 1961, a few first instar larvae were observed feeding on the balsam woolly aphid. The population was small and somewhat erratically scattered throughout the stand. By April 27, most of the larval population was ready to pupate. Five adult predators reared from a collection made at that time were sent for identification, along with several P. impexus adults received in the original shipment from Europe, to Dr. Melville Hatch of the University of Washington. Dr. Hatch's determinations confirmed that the reared specimens were P. impexus.

Neither adults nor larvae of P. impexus were seen again in the area. This suggests that the colony may have failed to establish. The area will be closely inspected in 1962.

MISCELLANEOUS

This section concludes two unrelated subjects left unanswered in last year's report: (1) The results of a test to overwinter three predator species received from Pakistan and India in late 1960, and (2) the final determination of a native predator in the genus Laricobius.

The three predator species--Adalia tetraspilota, Exochomus uropygialus Muls., and Harmonia breiti Mader--were overwintered in a laboratory refrigerator at 34° F. Of the three species, representing 135 specimens, only 12 H. breiti were still alive in the spring of 1961. These surviving specimens were caged with an aphid-infested log. The insects were quite active for a few days but soon became quiescent and began to die. On March 1, 1962, 16 months after the insect shipment was received, the last adult died. Other than occasional feeding on honey, there was only one break during this long population decline: In mid-October, when only four adults remained alive (and were 12 months old), 32 eggs were laid. None of the eggs, however, proved viable.

The other subject to be discussed in this section concerns the final determination of the native Laricobius species found attacking native chermids (and once C. piceae) in Oregon's Willamette Valley. Last year's report stated that the insect appeared to be a new species, although superficially similar to the native L. nigrinus Fender. After seeing a longer series of adults, Mr. K. M. Fender of McMinnville, Oregon, reversed his earlier decision and identified the insect as L. nigrinus, the same species he described in 1945.

PROJECT PERSONNEL

Entomologist K. H. Wright, Division of Forest Insect Research, Pacific Northwest Forest and Range Experiment Station, was responsible for the overall direction and coordination of the balsam woolly aphid project. Entomologist R. G. Mitchell was responsible for the detailed planning of the project as a whole, organization and technical guidance of summer help, laboratory rearing, and reporting study results. Field work on predator introduction and assessment was headed, until July 1, 1961, by Entomologist P. E. Buffam. Helping on the project and taking over when Buffam transferred to National Forest Administration, was biological aid R. H. Heitmanek. G. W. Martin, the biological aid who served as laboratory assistant at Sellwood, assisted part-time in mounting insects and maintaining rearings as his other duties permitted.